VARIABILITY OF THE SURFACE CIRCULATION AND TEMPERATURE IN THE ADRIATIC SEA

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LONG-TERM GOALS

My long-term goals are to contribute to the understanding of the dynamics of marginal seas such as the Adriatic by collecting and interpreting observations of currents and water mass properties (e.g., temperature). In particular I am very interested in studying the impact of the wind forcing and fresh water runoffs on the circulation. Also of interest to me is the study of the variability of the surface velocity and temperature fields in the Adriatic at the meso-, seasonal and interannual scales.

OBJECTIVES

The first objective is to assess the quality of historical drifter data sets, i.e., to intercompare the water-following capabilities of the various drifters operated in the Adriatic Sea, to apply adequate corrections and to merge these data sets to obtain a useful multi-year drifter data base for the Adriatic.

The second goal is to use historical and new drifter observations, along with satellite thermal images, to describe the spatial characteristics and the temporal variability of the surface circulation and the sea surface temperature (SST) in the global Adriatic basin, at inertial to seasonal scales.

The third objective is to investigate some aspects of the response of the surface circulation and SST to atmospheric and boundary forcings. In particular, our goal is to study the characteristics of the wind-driven currents in relation to the surface wind forcing, obtained from wind measurements and from atmospheric model products. A related aim is to explore the role of eddies (versus mean currents) in transporting momentum and heat.

APPROACH

The first step is to analyze and interpret combined surface drifter data sets collected by the SACLANT Undersea Research Centre (SACLANTCEN) and by the Naval Oceanographic Office (NAVOCEANO) in the Adriatic in the early and mid 1990's (see schematic diagrams of the drifters in Fig. 1). In

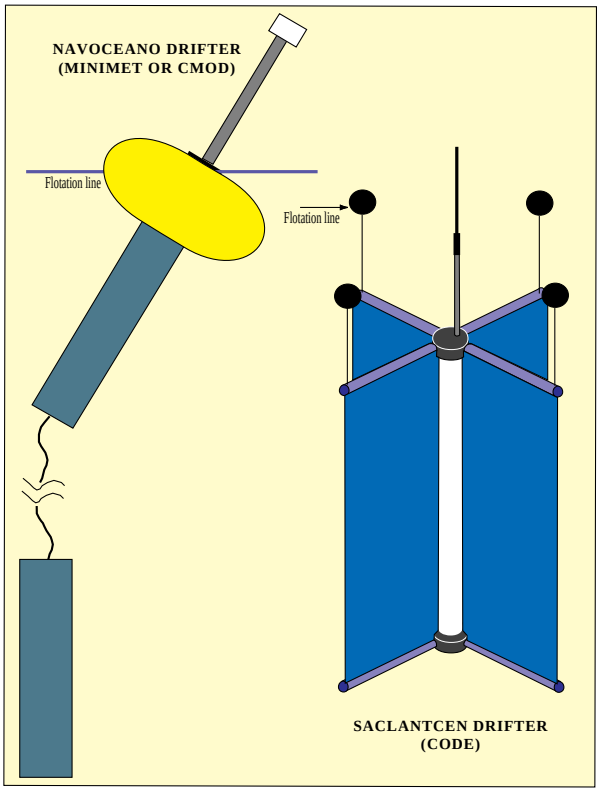

Fig. 1 Schematics of the surface drifters operated by NAVOCEANO and SACLANTCEN. Most NAVOCEANO drifters were drogued to 4 m and a few of them to 100 m. THE SACLANTCEN drifters measure the currents within the first meter

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order to combine the different drifter data sets a quantitative comparison study of the water-following capabilities of the drifter systems used will be performed. Satellite AVHRR images archived by SACLANTCEN between May and October 1995 will be processed to provide navigated and calibrated SST maps. The SACLANTCEN and NAVOCEANO drifter observations will be confronted with concurrent satellite thermal images. A qualitative description of surface currents and SST using drifter trajectories superimposed on AVHRR images (or image composites) and a quantitative statistical comparison of satellite- and drifter-inferred SSTs will be performed.

The second step is to make new effective measurements of the surface currents and SST in the global Adriatic basin with particular attention to the seasonal variability of the circulation and to the major forcings. Releases and tracking of low-cost Lagrangian CODE drifters will be conducted to achieve this goal. Satellite infrared imagery will be used to provide additional measurements of the surface currents and the surface temperature fields.

WORK COMPLETED

The data from 172 drifters operated by NAVOCEANO between 1991 and 1996 were acquired in raw format. The data were quality controlled, reduced and edited for obvious outliers. Data points corresponding to drifters stuck on land or sailing on board ships were discarded. The NAVOCEANO and SACLANTCEN (Poulain, 1997; Poulain and Zanasca, 1997) drifter data bases were searched to find drifters of both types in the same area during the same time period. Two cases were found, one in the southeastern Adriatic and another one in the Strait of Sicily. As an example, the trajectories and latitude, longitude and velocity time series of two close-by drifters in the Strait of Sicily are displayed in Figs. 2a and 2b.

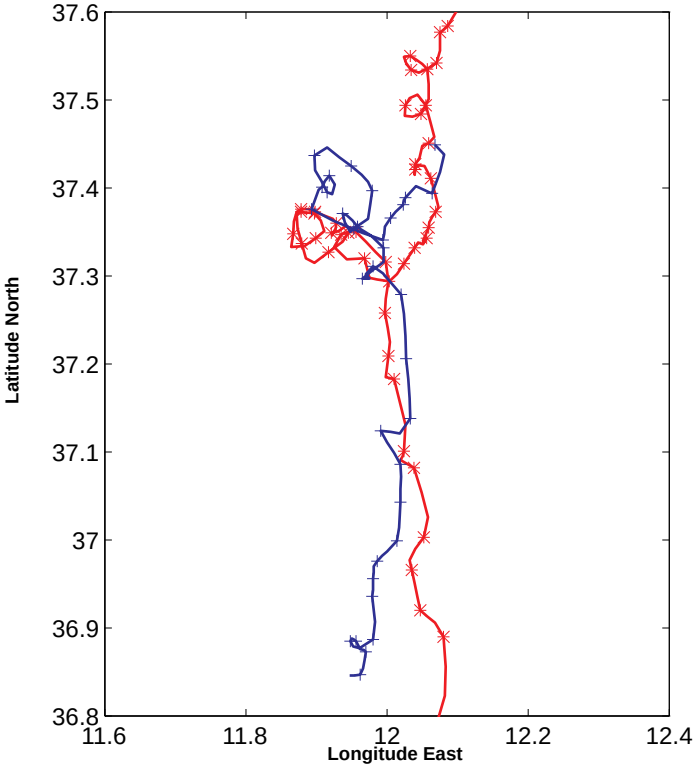

Fig. 2a. Trajectories of NAVOCEANO drifter 6430 (red) and SACLANTCEN drifter 24113 (blue) between 23 July and 2 August 1995. Symbols are drawn every 6 hours along the tracks.

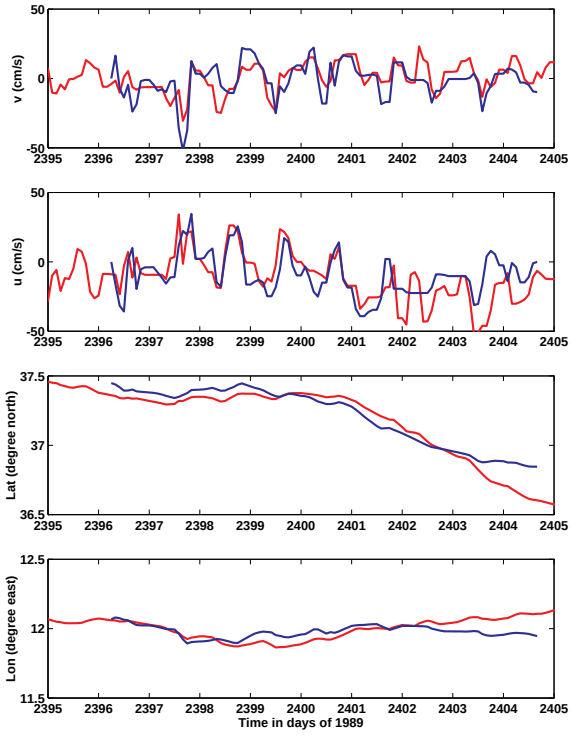

Fig. 2b. Time series of latitude, longitude and the two components of velocity for the NAVOCEANO (red) and SACLANTCEN (blue) drifters.

A total of 20 CODE drifters and one GDP/MINIMET drifter were successfully deployed between 22 August and 17 September 1997 by colleagues of the Osservatorio Geofisico Sperimentale (OGS). Six of the CODE drifters were provided by OGS. In the central and southern Adriatic, the drifters were deployed during the MATER02-97 cruise (MATER, 1997). In-situ wind observations were made following the release of the GDP/MINIMET drifter. One CODE drifter was repetitively deployed and recovered off Ancona, Italy in the area sampled by a newly-installed CODAR system in order to compare the surface velocity estimates obtained by the HF radar and CODE drifters.

The drifter data have been downloaded from Service Argos on a daily basis. After some pre-processing and data reduction, graphical representations of the drifter statistics, of the drifter trajectories and the temperature time series, etc. have been produced and updated every day in a dedicated world wide web page (NPS, 1997).

RESULTS

The comparison of the drift characteristics of a pair of NAVOCEANO and SACLANTCEN drifters reveals that both systems follow the water similarly. Mean displacements and high frequency oscillations due to tides and inertial motions are not significantly different when the systems are contemporaneously within 10 km of each other (Figs. 2a and 2b). Wind products will be acquired to correlate the wind speeds to the drifter velocities and to study the wind-produced slippage of both systems. We expect the water-following capabilities of the NAVOCEANO and SACLANTCEN drifters to be similar.

The GDP/MINIMET drifter successfully deployed in the center of the southern Adriatic showed the general cyclonic circulation around the South Adriatic Pit along with strong inertial motions. The acoustic data obtained appear good but have not been processed yet. It is planned to compare the wind speed and direction provided by the drifter to the ship observations and to wind products or satellite winds and to use the drifter-inferred winds in our study of the impact of the wind forcing on the surface circulation.

As of 29 October 1997, 12 CODE drifters were still reporting good position

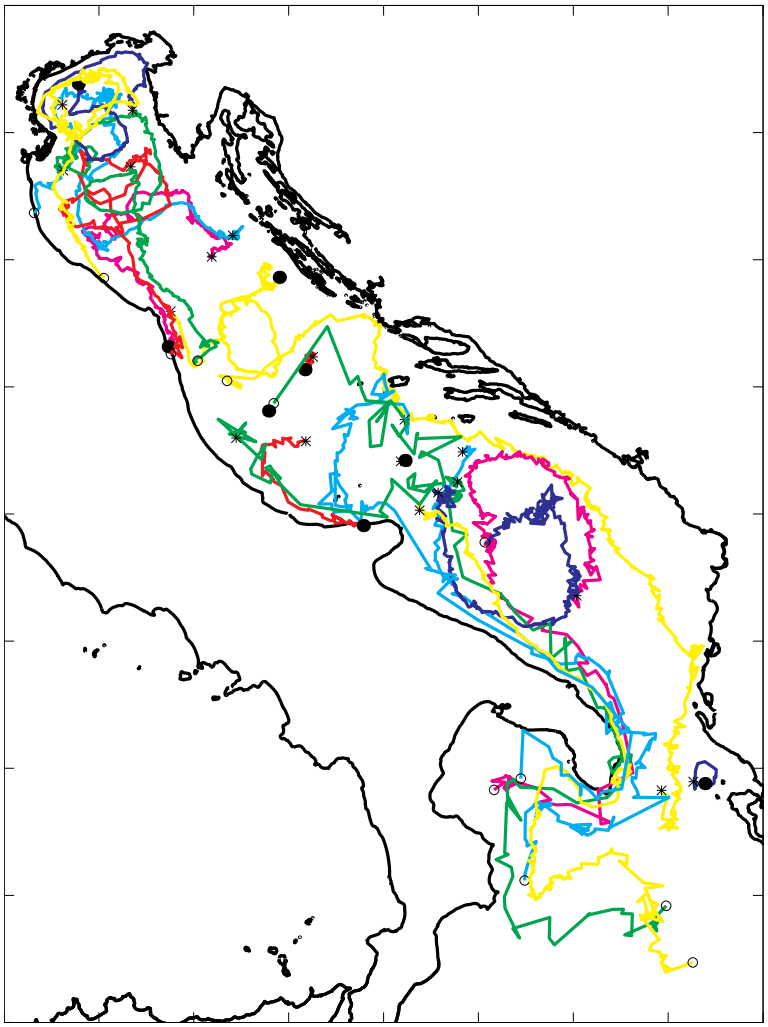

Fig. 3. Trajectories of the CODE drifters between 22 August and 29 October 1997. Star and circle symbols denote deployment sites and last fixes, respectively. Solid black circles indicate that the drifters stopped to operate before 29 October. The trajectories have been edited for displacement outliers corresponding to speed in excess of 80 cm/s.

and temperature data. Five of them had escaped into the Ionian Sea with the strong coastal current along the Italian Peninsula and through the western part of the Strait of Otranto (Fig. 3). A strong cyclonic gyre around the South Adriatic Pit was shown by two drifters. A cyclonic circulation feature at the end of the Adriatic north of 45°N is evident. Between 43°N and 45°N, although the drifters released to the east showed a cyclonic veering of the northwestward currents and eventually joined the southeastward coastal current along Italy, the surface circulation appeared quite complex and highly variable with time.

IMPACT/APPLICATIONS

The scientific impact of this project will be to increase our understanding of the Adriatic Sea dynamics and of the major forcing mechanisms. Future application could be the assimilation of the drifter data into numerical models in the framework of the anticipated Mediterranean Forecasting System.

TRANSITIONS

Graphical representations of the drifter data are readily available on the world wide web (NPS, 1997) not only to keep the P.I. and all the collaborators abreast of the drifter movements and to help with the planning of subsequent releases but, most importantly, to disseminate the information to anyone interested, specifically to provide quasi-real time environmental parameters for rescue, military and fisheries operations.

The sea surface temperature data are directly distributed onto the Global Telecommunication System (GTS), a network operated by National Meteorological Services to exchange data on a global basis. In this way, the drifter SSTs are directly used and assimilated into models for weather forecasting.

The drifter data will be used by European scientists working on the deep water formation mechanisms in the southern Adriatic as part of the MATER program (MATER, 1997).

This program proves the usefulness of the drifters that NAVOCEANO has been (and is currently) using to obtain environmental observations during sea operations, to quantitatively estimate surface currents. It is planned to assimilate the drifter data (velocities and SST) into Navy operational numerical models of the circulation in the Adriatic to improve forecasting skills.

RELATED PROJECTS

NATO Rapid Response 1997 in the Adriatic and Ionian Seas: CODE drifters have been released during this exercise organized by SACLANTCEN. The drifters funded by our ONR project and the new SACLANTCEN drifters will be combined, for instance, to study the circulation in the Ionian Sea.

Italian PRISMA Project: Hydrographic surveys in the western Adriatic and HF radar observations off Ancona, Italy, as part of the Italian project "Programma di RIcerca e Sperimentazione per il Mare Adriatico" (PRISMA-2a) are closely related to this project.

MATER Project: Surveys in the southern Adriatic and strait of Otranto (MATER, 1997) to study the mechanisms of formation and spreading of deep Adriatic water. The majority of the drifters of our ONR project are released during these surveys. Most of the hydrographic and drifter data will be shared and joint publications will be written.

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